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PUBLIC HEALTH
IN THEORY AND PRACTICE

PUBLISHED UNDER THE AUSPICES OF THE
YALE SCHOOL OF MEDICINE
ON THE FOUNDATION ESTABLISHED IN MEMORY OF
WILLIAM CHAUNCEY WILLIAMS, M.D.,
OF THE CLASS OF 1822, YALE MEDICAL SCHOOL,
AND OF
WILLIAM COOK WILLIAMS, M.D.,
OF THE CLASS OF 1850, YALE MEDICAL SCHOOL

The Second
William Thompson Sedgwick Memorial Lecture

Delivered in Huntington Hall, Boston, Massachusetts, January 25, 1924.

For the purpose of commemorating the services of William Thompson Sedgwick to the cause of Biology and Public Health there has been established a Memorial Lectureship in the department of the Massachusetts Institute of Technology which he created. The desire of the founders is that the Sedgwick Memorial Lectures shall be given from year to year by men of distinguished eminence in any one of the subjects comprehended within the general scope of Biology and Public Health in order that it may fittingly express the deep and broad sympathy of the man whom the Lectureship is designed to honor.

PUBLIC HEALTH

IN THEORY AND PRACTICE

An Historical Review

BY

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THE present volume is the eighth work published by the Yale University Press on the Williams Memorial Publication Fund. This Foundation was established June 15, 1916, by a gift made to Yale University by George C. F. Williams, M.D., of Hartford, a member of the Class of 1878, Yale School of Medicine, where three generations of his family studied—his father, William Cook Williams, M.D., in the Class of 1850, and his grandfather, William Chauncey Williams, M.D., in the Class of 1822.

Public Health in Theory and Practice*

NO form of recognition to perpetuate his memory could have been more acceptable to William T. Sedgwick than the foundation of a lectureship in this Institute, intended, as we have just been told by Professor Prescott, to expound progress in the biological and sanitary fields of knowledge with which his name is so prominently identified.

Sedgwick, after graduating from the Sheffield Scientific School of Yale University, became one of that remarkable group of early fellows in biology under Newell Martin at Johns Hopkins University, including, among others, William K. Brooks, E. B. Wilson, Thomas H. Morgan, and William H. Howell, who have influenced so profoundly the development of bi-

* The Second Annual Sedgwick Memorial Lecture, delivered at the Massachusetts Institute of Technology, January 25, 1924.

ology and physiology in this country, an influence comparable to the earlier one of Agassiz in zoölogy. This new spirit and these new methods Sedgwick brought with him when he was called in 1883 to the chair of biology, to which was subsequently added at his desire the title of "public health," in the Massachusetts Institute of Technology.

He was already interested in the new fields of bacteriology opened to exploration by the work of Pasteur and of Koch. In the application of these revolutionary discoveries to sanitary science and practice, Sedgwick, by his investigations and especially by the remarkably stimulating influence of his teaching, was a pioneer in this country. His valuable scientific contributions, often in coöperation with his students, in the earlier years related largely to such subjects as the bacteriology of water, ice, air, milk, foods, and kindred topics of importance to sanitation.

Although a useful contributor to science and an admirable writer, Sedgwick belongs to the class of great teachers whose fame is spread and perpetuated by his students and disciples and by

personal tradition. When one recalls among the hundreds of men and women directly influenced by Sedgwick such names as those of Hazen, Fuller, Jordan, Winslow, Whipple, Prescott, and Gunn, he can realize that Sedgwick was the most influential teacher of public health of his day in this country.

A great opportunity came to him by his appointment as Consulting Biologist, coincident with that of Drown as Consulting Chemist, to the Lawrence Experiment Station, established in 1887 by the Massachusetts State Board of Health, following the reorganization of the latter the year before. From the coöperative work of this Station and of the Institute of Technology, conducted by an able group of chemists, biologists, and engineers, there came those investigations of fundamental problems of water supply and sewage disposal which constitute the first and to this day remain among the most important contributions to sanitation made in our country. These studies and the somewhat later establishment and development by the New York City Department of Health, under the

stimulus of Hermann Biggs, of the public health laboratory as an essential part of governmental health organization and of the administrative control of disease are in my judgment the two most important contributions which America has made to the principles and practice of public health, and Sedgwick's is one of the names which will always be connected with the first of these.

Among the more important epidemiological and sanitary studies with which Sedgwick was associated, especial mention should be made of the investigation of the epidemic of typhoid fever which broke out in the Merrimac Valley in 1890. The study of this epidemic, as is well known, is one of the best on record, and proved to be of great influence in the introduction of central filtration of public water supplies and in improving the methods of control of water-borne typhoid in this country. As has been the case with many other pestilences, this one eventually led to the saving of many more lives than it destroyed.

Nor should we forget in recalling some of

his many services to public health the active share of Sedgwick in the joint undertaking of the Massachusetts Institute of Technology and the Harvard University Medical School in providing opportunities, as good as the resources then permitted, for the special training of those desiring to enter careers in public health.

Truly the cause of public health in city, state, and nation is deeply indebted to the inspiration, writings, and teaching of this great leader, and this Institute will ever cherish the name and fame of one who served her so devotedly for thirty-five years.

Professor Whipple tells us, in his interesting account of Professor Sedgwick's contributions to public health, published shortly after the latter's death in 1921, that the opening sentence of his first lecture given to students of engineering in biology and bacteriology was: "The sanitarian needs a proper working theory," whereupon the lecturer passed to the exposition of the then recently established germ theory of disease. It is considerations suggested by this

pregnant sentence of Sedgwick that I desire to make the principal subject of my remarks on this occasion.

THE working hypothesis plays as important a part in the advancement and application of knowledge in the fields of biology and medicine as in those of the more exact sciences—physics and chemistry—but it is concerned with far more complex phenomena in the case of the former and, therefore, with advancing knowledge, is less likely to be confirmed than in the case of subjects the phenomena of which are more readily open to correct interpretation from observation and experiment.

Working hypotheses for the preservation of health and protection from disease have existed and been applied in all ages, and have always been based upon opinions entertained concerning the workings of the human body and the origin, nature, and mode of spread of disease. The attribution of disease to the anger of an offended deity or to the malign influence of the stars is as truly a working hypothesis for disease prevention as is the germ theory of disease, and

has held sway immeasurably longer, nor has it wholly disappeared in our day.

To attempt to trace historically the evolution of all of these working hypotheses and their influence upon efforts to control disease is a subject far beyond the limits of an address, for it would be nothing less than to write the whole history of medicine from the point of view of the conceptions held concerning the nature of disease. It is these conceptions which in the past not less than to-day have determined the measures deemed applicable to the prevention of disease. The subject is full of interest and for its comprehensive treatment awaits a future historian. On this occasion I shall attempt to direct your attention to only a few salient features of some interest in present conditions.

Leaving out of account superstitious views and confining oneself to rational medicine, one is struck, first, by the relatively slight importance attached in antiquity to the idea of contagion, as contrasted with that of miasm conveyed through the atmosphere, to account for the origin and spread of endemic and epidemic diseases. It is

true that in the Mosaic sanitary code, as well as in the writings of Thucydides, Lucretius, and other lay writers, contagion plays an important rôle; nor is the conception wholly absent from the works of Hippocrates, Galen, and other classical medical writers, but, in these works, which were the mainspring of subsequent medical theory and practice, by far the greater emphasis is laid upon the doctrine of miasm. The very title of the important Hippocratic book, the first on sanitation, *On Airs, Waters, and Places*, is significant of the point of view. The opinions held as to the sources of infection, whether from man or from the outer world or from both, determine the character of intelligent measures of prevention.

Weighty arguments were adduced by ancient writers in support of the miasmatic hypothesis—far more convincing ones than were brought forward a generation and more ago for one of its modern manifestations in the sewer-gas hypothesis of the origin of diphtheria and other diseases, or even for Murchison's pythogenic origin of fevers.

It would be difficult to exaggerate the importance of this doctrine of miasm in the history of preventive and curative medicine, for it survived the authority of Hippocrates and Galen up to our own time, and has been displaced from its dominant position only in our day by knowledge of the living agents of infection, although, as I shall point out presently, the idea of contagion had been forced long before this upon the reluctant minds of physicians.

A second important doctrine or working hypothesis which dates from classical antiquity and has exerted great influence throughout medical history, being much to the front at the present time, is that of the individual constitution or diathesis, either inherited or acquired, as a determinant not only of susceptibility to disease but also of the character of disease itself as manifested by its course, symptoms, and lesions. Upon this was based that cult of personal hygiene, that is, the strengthening of the constitution by exercise, dietetics, bathing, care of the body, and life in the open, which was practised by the ancient Greeks with an intelligence and

to a degree not surpassed even in our own day. I shall refer later to the expansion of this doctrine of the constitution by Sydenham to a form of great influence upon the subsequent history of epidemiology.

We know from the writings of Frontinus and of Vitruvius that sanitation of the environment was an idea familiar to the ancient Romans, whose practical sense and administrative genius enabled them to give application to ideas and principles originating with the Greeks. Inasmuch as sanitary improvements fortunately contribute to convenience, comfort, and pleasure as well as to health, it is by no means easy to estimate the relative force of each of these motives in providing these improvements. Whatever the incentive, it is certain that only during the last century has the world seen anything approaching the great works of the Romans, ministering to sanitation, in the way of public water supplies, sewers, roads and pavements, prevention of nuisances, control of markets, sanitary construction and supervision of public buildings and military camps, and census-taking.

With the reaction against paganism following the fall of the Roman Empire came the asceticism, the other-worldliness, the misery, the barbarism, and the intellectual decline of the Dark Ages, accompanied by conditions of neglect of personal and public hygiene more appalling than the world has seen before or since that period.

But out of the thousand and more years of mediævalism Europe emerged with two practical ideas of great significance to public health. One was the spirit of Christian sympathy leading to the establishment of hospitals and the care of the sick, and, much later, in the eighteenth century, in part contributing, through the so-called evangelistic movement in England, to the development of that "new humanity" which so powerfully stimulated the humanitarian and sanitary movements of the early nineteenth century.

The other idea, more immediately medical and hygienic, was the recognition of contagion with the resulting practical application of this doctrine to the control of certain epidemic diseases by means of isolation and quarantine. As

already pointed out, the Hebrew scriptures lent support to the idea and to the enforcement of these preventive measures even in extreme form. But it was the terrible pestilences of the middle ages—small-pox, leprosy, plague, typhus, and, at the end of the fifteenth century, syphilis—which forced irresistibly upon the mind of the public, perhaps even more than upon physicians, bound, as they were, by the dogmas of Galen, the belief in the conveyance of these diseases by human contact.

The greatest triumph to be credited to the principle of isolation is undoubtedly the eradication of leprosy from most of western Europe by the application of this measure in an extreme, even inhuman manner. In our own day leprosy is on the way to extinction in Norway, where it has lingered after its disappearance elsewhere in most of Europe, as the result of a return to effective isolation. To no other disease has isolation been applied with equal stringency, and it is questionable whether any other human disease would be equally amenable to this method of prevention.

Quarantine was introduced by Venice in the fourteenth century especially to combat the entrance of plague from the Levant, and for reasons now well known was not attended by marked success.

No disease is better adapted to impress the idea of its transmission by direct contact than is syphilis, which spread over Europe in so extraordinary and devastating a manner at the close of the fifteenth and in the early part of the sixteenth centuries. It was especially under this impression that the accomplished Italian humanist and physician, Fracastorius, in 1546, formulated and discussed the doctrine of contagion with an acuteness of reasoning and a clearness and breadth of conception most remarkable for the time and not surpassed before the discovery in recent years of the actual agents of infection.

Fracastorius sharply separated *contagia* from poisons, recognized that they propagate themselves and breed true, and distinguished clearly those which act by direct contact, those which are conveyed by *fomites*, and those which are carried from their source to a distance. One ex-

pects him on every page to say that his "*seminaria contagionis*," which he thus endows with properties of life, are in fact living organisms, but he does not say it. Nevertheless, his conceptions and reasoning on the general subject of contagion are far in advance of those of most of the later champions of the doctrine of animate *contagia* on purely *a priori* grounds.

In this celebrated work of Fracastorius we find a striking example, not uncommon in the history of science, of the formulation of a working hypothesis born before its time and capable, in this instance, of fruitful application to a better understanding and control of disease. More complete evidence than Fracastorius could furnish was needed for the general acceptance of the correctness of his views on contagion, and it does not appear that his work had any important influence upon his contemporaries or, for the following four centuries, upon his successors.

Passing over contributions to our knowledge of disease made in the century following Fracastorius as, however interesting, less directly related to our present theme, we come in the latter

half of the seventeenth century to the first great epidemiologist, Sydenham, who represents for the natural history of disease in spirit and in method what his contemporary, Ray, does for natural history in general. He returned to the Hippocratic method of direct, painstaking observation, and was little influenced by dogmatic authority. Although not so free from speculative tendencies as he is sometimes represented, he indulged comparatively little in vain speculations.

We are less concerned here with Sydenham's admirable descriptions and first recognition of certain epidemic diseases, as scarlet fever, than with the hypothesis, which he advanced, under the designation of "epidemic constitution" or "*genius epidemicus*," to account for the occurrence of epidemics in waves, for their rise and fall, and for variations in their character according to season, climate, locality, and individual predisposition. Here Sydenham for the first time penetrated to problems of epidemiology of fundamental importance, which perplex us today, and are the subject of intensive investigation. The approach to their solution by the ex-

perimental method is one of the surprising, and, it is to be hoped, promising lines of attack. We may feel assured that explanations, when found, of certain of these mysterious characteristics of epidemic diseases will furnish a clue to their more effective control.

The eighteenth century, although called "the philosophical century" and, in medical history, that of the systematists, was marked by some of the greatest triumphs in the history of preventive medicine, and above all by the first successful application of the principle of active immunization in the discovery of vaccination against small-pox by Jenner. It was a period of great development of experimental science, which had been initiated a century before by Galileo, Gilbert, and Kepler, and from its latter half date the Industrial Revolution and the beginnings of political, social, and humanitarian movements highly significant for the future development of public health.

In 1720 Richard Mead, in his *Short Discourse Concerning Pestilential Contagion,* sets forth far more advanced and enlightened views

concerning isolation, quarantine, and continued observation of contacts than had hitherto prevailed.

Fascinating is the story of Sir George Baker's elimination of Devonshire colic as the result of his demonstration that poisoning by lead used in utensils employed in the manufacture of cider was its cause. The hostility aroused against Baker, himself a Devonshire man, for his disloyal contention that the good cider of Devonshire was responsible for the palsies and colics prevailing there was paralleled on a larger scale in recent times by the bitter antagonism of patriotic citizens of California against those who first announced the appearance of bubonic plague in that state. Unique in history was the practical submission of the question to popular vote in the campaign for election of governor.

Of far wider significance, indeed an historical event of the first importance, was the conquest of the great scourge of scurvy through the treatise of James Lind published in 1753, and the brilliant achievement of Captain Cook in completing in 1775 a voyage of over three years

with the loss of only one member of the crew by disease. Scurvy is a striking example of the length of time it may take for a scientific discovery to be applied. That two hundred years should have elapsed after the discovery that scurvy is controllable by the use of fresh vegetables and lemons before the use of lemon juice in the British Navy was made compulsory in 1796 furnished Herbert Spencer with an effective illustration of administrative torpor.

The prevention of scurvy has an especial interest for the influence which it had upon the improvement of personal hygiene and of ship hygiene and especially as the first instance of the control of a disease by diet. Only in recent years, and doubtless even now inadequately, have we come to some understanding and appreciation of the importance of diet in personal and public hygiene and preventive medicine. The elucidation of the principle involved in the prevention of scurvy and of other diseases due to dietary deficiencies or imbalance, as beri-beri and rickets, constitutes one of the most important recent contributions to preventive and curative medicine.

In the same line, although involving a different principle, is the prevention of endemic goitre by taking iodine.

The discovery of a successful method of artificial, active immunization against small-pox we now recognize as not only the greatest single triumph hitherto achieved by preventive medicine in the conquest of one of the most devastating scourges of mankind, but also, as in the case of prevention of scurvy, as the introduction of a new principle and method for the control of disease of far-reaching application. Leaving out of account the more or less legendary tales of mithridatism and certain practices of primitive and oriental peoples, we must date the first intelligent and systematic use of artificial active immunization from the introduction in 1717 into England by Lady Mary Wortley Montagu of the practice of inoculation against small-pox, followed shortly afterward and independently by its employment in Boston by Dr. Boylston through the efforts of Cotton Mather. The substitution of vaccination for inoculation by Jenner's immortal discovery in 1796 is so much the

more important event that we justly assign to him the main honor of the discovery, as is indicated by Behring's proposal to designate experimental active immunization as "Jennerization."

Again, as in the widely different case of scurvy, the first empirical discovery had to wait a long time for its further application and for the scientific investigation of the principle concerned.

It was not until 1880 that the second step was taken by Pasteur in his discovery of experimental immunization against chicken cholera, soon followed by his studies of immunity from anthrax and rabies and by later ones by others of vaccination against typhoid fever, cholera, plague, yellow fever, and other diseases. Thus, a century and more after Jenner's discovery, the powerful weapon which he first employed, little dreaming of its possibilities, has been forged for attack upon a number of infectious diseases and the end is not yet.

If my purpose were to trace the historical development of the modern movement for public health, which has been done recently with char-

acteristic skill and charm by Professor Winslow in his admirable Yale address, "The Evolution and Significance of the Modern Public Health Campaign," I should wish to say something more concerning the contributions of the eighteenth century to this movement. I should then desire to dwell on the progress made in statistical inquiries, initiated in the preceding century by Capt. John Graunt, Sir William Petty, and Halley; the foundation of modern army hygiene by Pringle, the intimate friend of Benjamin Franklin; the work of Thomas Percival of Manchester, who was the first to recognize the significance of the new conditions of living and working introduced by the Industrial Revolution in the causation and spread of epidemic fevers, and of his friend, John Haygarth, who applied statistical methods to the study of epidemics in Chester, and introduced in 1774 modern methods of isolation of fever patients in a hospital in that city. The memorable services of John Howard of imperishable fame in prison reform would be recalled as significant for pub-

lic health as well as for the humanitarian movement.

One cannot read the story of the contributions of the eighteenth century to science, to medicine, to hygiene, to movements for social and political reform, while at the same time considering the effects of the Industrial Revolution, without being convinced that the Napoleonic wars delayed for a generation the sanitary legislation and the creation of the General Board of Health of 1848 in England, from which we date the modern public health era, for then for the first time in human history was the care of the health of the people fully recognized as an important administrative function of Government.

Something of the story of the various influences, movements, and events which culminated in this great sanitary awakening is told by Winslow in his Yale address, but every student of public health should read again and again the complete story as told so fascinatingly and authoritatively by Sir John Simon in his *English Sanitary Institutions*. Next to Edwin Chadwick,

Simon was the great protagonist of the new movement, and hardly second in importance, although in a different line, was the eminent statistician, William Farr, who made literature out of statistics. Most of the medical ammunition in the formative period was supplied by reports of the Poor-Law Commissioners incorporating the surveys of Southwood Smith. I am inclined to think that Jeremy Bentham, of whom Chadwick was a disciple and close friend and with whom he lived, had more of a guiding hand than has been assigned to him. Certainly his discussion of the subject of public health and his detailed elaboration of a plan of organization of governmental health activities are of extraordinary interest and contain ideas and suggestions embodied in the legislation of 1848.

The Edwin Chadwick of America was Lemuel Shattuck, who, like Chadwick, was not a physician but a student of social problems. The "Report of the Massachusetts Sanitary Commission" in 1850, drafted by Shattuck under the influence of Chadwick's publications, and now readily accessible in Whipple's *State Sanitation,* presents a

program of public health organization and activities even more broadly conceived than that of Chadwick, and not completely realized even at the present day. This report, being unaccompanied by any such startling array of facts and figures as that which gave irresistible force to Chadwick's appeal, had no corresponding influence, so that it was not until 1869 that the first State Board of Health was established in Massachusetts.

How important it is to accompany such reports and appeals by facts revealed by a sanitary survey is illustrated by the successful campaign of the Citizens' Association of New York City in securing the passage in 1866 of the famous Metropolitan Health Law of that city, drafted by Dorman B. Eaton after the survey conducted under the supervision of Dr. Stephen Smith, by which the New York City Board of Health was established. No equally extensive powers, administrative, legislative, and judicial, have ever been conferred upon any other board of health, nor are they likely to be.

Our concern, however, on the present occasion

is less with history as such than with ideas and theories underlying health activities, and we now turn to an inquiry concerning the conceptions of communicable diseases which guided organized hygiene and preventive medicine as they entered upon their new opportunities in 1848 and which they followed for the succeeding three or four decades.

It is an interesting coincidence that Pasteur began his studies of tartrate crystals in the same year in which the General Board of Health was created. Within a decade and a half he had studied the distribution of bacteria and had made clear their rôle and that of yeasts in the processes of fermentation and putrefaction, which had long been recognized as presenting such analogies to certain infectious diseases that the epithet *zymotic* had been applied to the latter. It had even been predicted that an understanding of these processes of nature would supply the key to an insight into the causation and characters of zymotic fevers.

There is some food for thought in the fact that, while a surgeon, Lister, immortalized his

name by applying Pasteur's discoveries to the prevention of accidental surgical infections, even before the actual agents of these infections had been recognized, not only did no sanitarian thus early see the bearing of these discoveries upon his field of disease prevention, but the official opinion, as expressed by sanitary authorities at that time, was definitely hostile to the germ theory of disease.

I attach, however, no great importance to this circumstance, for it is not clear what practical use sanitarians would have made of this theory with the knowledge existing at that time. Hypotheses born before their time are often sterile. They must have some relation to the state of knowledge existing at the time, and history affords many instances of the useful purpose served for a time by inadequate and even erroneous theories.

It is doubtful whether any more useful working hypothesis concerning the sources of epidemics could have been framed in 1848 than that which guided most of the sanitary activities at that period and for many subsequent years,

erroneous as it was and tenaciously as it was held after it had served its primary purpose. This doctrine, as is well known, was the so-called filth theory of the generation of epidemic diseases, particularly of typhus, typhoid, dysentery, and cholera, which were the most serious scourges to combat.

The acceptance of this theory led to a campaign for the supply of pure water, the proper disposal of sewage and prevention of water pollution, the removal of nuisances, the cleanliness of streets, the inspection of food, the healthfulness of dwellings, ventilation, provision for burial of the dead without injury to the living, in a word, for "general cleaning up." Thus were laid the essential foundations of modern sanitation of the environment, and much of the routine technique of the present-day health officer, particularly of sanitary inspectors, was established in this early period. Many will sympathize with Chapin's vigorous protest against the waste of time and money spent by modern health officers or their employes in inspection and re-

moval of nuisances of little or no sanitary importance.

At the same time registration of deaths and sickness was effectively carried out in the Registrar-General's Office, which was established ten years before the General Board of Health was constituted, and from which issued those delightful letters of William Farr conveying to the profession and the public the lessons to be drawn from vital statistics.

Isolation in fever hospitals of patients with contagious fevers was practised. There already existed hospitals for the care of consumptives, although with no thought of prevention of tuberculosis. Nevertheless, to the early and continued provision of these hospitals both Koch and Newsholme attribute a large share in that reduction of tuberculosis which in England antedated by many years a similar diminution in other countries and the bacteriological era.

Great as were the benefits to comfort and health of the new environmental sanitation, its results in the control of the spread of infectious diseases were distinctly disappointing. Epidemics

of cholera, typhus, typhoid, dysentery, relapsing fever, scarlet fever, and diphtheria continued to flourish and there were outbreaks of small-pox due to neglect of vaccination. Belief in the autochthonous origin of pestilential fevers from decaying organic matter and failure to recognize sufficiently the human sources of infection, particularly the direct and indirect conveyance of contagion by *excreta,* were the most serious errors of the working hypotheses guiding sanitary effort at that time.

That intelligent and careful epidemiological studies could have corrected many of these prevailing errors we know from the contemporary investigations of John Snow on cholera and of William Budd on typhoid fever, which remain to this day models of research by purely epidemiological methods. The Broad Street pump in Soho, London, demonstrated by Snow in 1854 to be responsible for the spread of Asiatic cholera has been spoken of by Sedgwick as the cornerstone of modern sanitary science. Snow and Budd we now recognize as the greatest epidemiologists of their day in England, but such, how-

ever, was not their reputation among contemporary sanitarians, who were influenced far more by the greater fame and authority of Murchison, the leading champion of the pythogenic origin of pestilential fevers, the epithet *pythogenic*, signifying *generated by putrefaction*, being of his own manufacture.

The truth is that sanitary science was groping blindly in the dark before the discovery of the living agents of infection. Nothing is more certain than the ineffectiveness of efforts to control communicable diseases in ignorance of their causation and mode of propagation, as witness yellow fever, malaria, plague, cholera, and a host of other diseases. Working hypotheses for the prevention of these diseases framed in absence of this knowledge are almost invariably wofully inadequate or actually false, so great are the difficulties of interpreting evidence furnished by mere observation in the domain of curative and preventive medicine.

At last the light came from the torch kindled by Pasteur. For a quarter of a century he had been laying the foundations of modern bacteri-

ology, but he did not actually attack problems of human infection until just about the time in the middle seventies when Koch entered the field and introduced those technical methods which led, in that golden decade of the eighties of the last century, in his hands and those of his followers to that marvelous series of discoveries of the parasitic microörganisms causing cholera, tuberculosis, pyogenic infections, including puerperal fever, typhoid fever, diphtheria, pneumonia, cerebrospinal meningitis, and other infectious diseases. Obermeier's spirochete of relapsing fever (1873) and Neisser's gonococcus (1879) were already known, and in 1881 Laveran discovered the protozoan parasite of malaria.

The special field so successfully cultivated by Pasteur in this *decennium mirabile* was that of immunity, his work, unsurpassed in ingenuity and of the utmost significance for public health, culminating in his dramatic discovery in 1885 of preventive inoculation against rabies.

The following decade, scarcely less remarkable, was marked by the introduction of vaccine

and serum therapy and prophylaxis, the discrimination between human and bovine tubercle bacilli by Theobald Smith, who had already by his studies of Texas cattle fever opened to exploration the highly important domain of insect-borne diseases, to which malaria, yellow fever, trypanosomiasis, and typhus belong. The close of the century was worthily crowned by the conquest of yellow fever by the discoveries of Walter Reed and his colleagues of the Army Yellow Fever Commission. The rôle of human carriers in the transmission of infection was made known, although full appreciation of the perplexing epidemiological problems thereby created did not come until the present century, which has continued to enrich our store of knowledge in the fields of hygiene and preventive medicine, as well as in other departments of medical science.

Thus within the last half century bacteriology, by revealing the microörganisms concerned in those diseases which are of the greatest racial and social importance to mankind, and by providing methods for the study of their charac-

ters and behavior, transformed public health from a blundering, empirical set of doctrines and practice to a science and laid secure foundations for its further development along scientific lines.

Here, by way of explanation, permit me to say in passing that public hygiene is not strictly speaking an independent, concrete science in the sense in which we apply this term to anatomy, physiology, or pathology, but is the application of various sciences, as chemistry, physics, zoology, physiology, bacteriology, pathology, engineering, statistics, and still others, to the end of preserving and improving health and preventing disease. This end, however, is so important, specialized, and definite that it gives coherence to the body of doctrines and their application derived from other sciences for its attainment. In this sense, and in this sense only, there is no impropriety in speaking of the science and art of hygiene or public health, and there is much convenience in this usage.

America and more particularly the New York City Department of Health, through the efforts

and stimulus of the far-sighted late Hermann Biggs, had a leading share in applying the new bacteriological discoveries to the administrative control of disease, its most important instrument for this purpose being the diagnostic and bacteriological laboratories, established in 1892, first for the diagnosis of cholera, which had appeared on ships from Hamburg then detained in New York harbor, and soon applied to the diagnosis of diphtheria and the manufacture of antitoxin, and the examination of sputum from suspected cases of tuberculosis. The subsequent development and contributions of these laboratories under the direction of Dr. William H. Park have been of great importance in the advancement of public health.

It might be asked whether sanitarians now as in the past have need of working hypotheses. Can they not be guided solely by scientific principles based upon accurate knowledge? No one aware of the inadequacy of existing knowledge or at all familiar with the history of public health during the modern period, which we are now considering, can doubt the answer. The sani-

tarian cannot await the ultimate solution of all the problems which face him. He must act according to his best judgment in the light of available knowledge, however inadequate this may be, and in so doing he must often frame hypotheses to guide him. Even when he believes himself to be possessed of sufficient knowledge for effective action, the results often show that he has been misled by erroneous deductions.

In illustration of what has been said it is interesting to consider certain characteristics and trends of public health work during the last forty years from the point of view of the underlying basis of knowledge and the prevailing beliefs and theories which have determined action.

In the early years of this period, after the discovery and cultivation of many pathogenic bacteria and their experimental inoculation into animals, the formulation of the problem of prevention of infectious diseases was believed to be relatively simple, however difficult the application of the requisite preventive measures might prove to be. There was a tendency to wide gen-

eralization from experience with a single disease. Anthrax was the paradigm, as it was for so many questions of infection and of disinfection put to laboratory tests. Years passed before it was clearly recognized that each infectious disease is a problem by itself. The specific microörganism, its special characters, its portals of invasion, its manifestations and behavior within the body, its channels of discharge, its survival and distribution in the outer world, were about all the questions that seemed to require consideration. Infection was believed to follow with practical certainty upon the entrance into the body of the virulent microbe in sufficient numbers. Older views of individual predisposition were widely discarded. I have heard Koch say that predisposition is merely proximity to the bacillus, and that it has no more to do with the chances of infection than it has with the chances of being hit by bullets in battle.

The measures requisite to prevent infection were obviously suggested by the foregoing considerations.

The most important of these measures were

early diagnosis and prompt isolation of the sick; quarantine of contacts; disinfection of infected discharges before their disposal, disinfection of the clothing, bed linen, and other effects which might serve as *fomites*, terminal disinfection and fumigation of rooms and premises occupied by the infected individual; avoidance of contact infection; in the case of water-borne infections, especial care given to the purity of water, milk, and foods or, failing that, to their sterilization by heat; and in the case of air-borne diseases to the prevention of the conveyance of disease germs in the form of dust and, somewhat later, greater emphasis upon droplet infection.

It is sometimes represented that this earliest program of prevention belongs to a bygone era. In spite of modifications in details, of changed emphasis upon some of the items, and above all of important additions necessitated by new knowledge, this program remains in my judgment as sound in its essentials as it ever was and as applicable to the control of many infectious diseases.

The principal modification relates to increased

emphasis upon the human sources of infection, and the chief omission to the increasing, although not the universal abandonment of terminal fumigation in accordance with Chapin's findings and recommendation. There is likewise growing, although perhaps not fully warranted, skepticism of the preventive value of municipal hospitals for isolation of cases of common infectious diseases, essential as these are for medical care and treatment.

The additions to these early methods of prevention resulting from advancement of knowledge are so numerous and important that they, in combination with new conceptions and points of view concerning personal and public hygiene, have greatly widened the field and broadened the outlook of public health during the present century.

No more striking illustration can be found of the necessity of a clear insight into the causation of disease for its successful control than the group of insect-borne diseases, of which the chief examples are malaria, yellow fever, the trypanosome diseases, and typhus, whose mode of

conveyance by insect hosts of their germs has been revealed during the last quarter century. The millions of money formerly expended for the eradication of yellow fever, and the same is largely true of typhus, under the influence of wrong hypotheses concerning their origin and propagation, might as well have been thrown into the gutter so far as any impression was made upon the incidence of these diseases. To-day the insect-borne diseases offer to the sanitarian the most promising lines of attack. Here and in the group of water-borne diseases, as typhoid fever and cholera, lie the greatest triumphs of modern preventive medicine, in contrast with our present comparative helplessness in the face of respiratory infections with the single exception of diphtheria, which has been successfully attacked by specific immunization.

The present-day anti-malarial campaigns, and especially the campaign for the complete eradication of yellow fever from the face of the globe, initiated by General Gorgas, which are both largely aided and supported by the International Health Board of the Rockefeller Foun-

dation, make a strong appeal to the imagination and have already attained a large measure of success.

Notwithstanding the unrivalled success of Jenner's active immunization against small-pox and the brilliant results of Pasteur in the eighties of the last century, it could not have been anticipated at the time of formulation of the early program for prevention of infectious diseases, which I have briefly outlined, that this procedure was destined to enter so largely into the *armamentarium* of the health officer, and of course there was not the slightest prevision of passive immunization by the use of immune serums, which was so soon afterward added by Behring and by Roux to his resources for the treatment and prophylaxis of diphtheria and by the former with Kitasato for tetanus. The protective value of vaccination against typhoid, demonstrated by Almroth Wright and more convincingly by Russell, was brilliantly confirmed on an enormous scale as a life-saving procedure of the first importance during the World War.

Further unsuspected possibilities of immunization in public health work have been recently made known by the development and introduction by Park of the method of active immunization against diphtheria by the use of toxin-antitoxin mixture, opening the way to complete control of this disease; by Noguchi's discovery of vaccine prophylaxis and serum therapy in yellow fever; by Park's temporary immunization against measles by the serum of convalescent and recovered patients; and by the interesting studies of scarlet fever by the Dicks, Dochez, and Blake.

In this connection I may be permitted to point out that these discoveries, as well as nearly all of those which have been successfully applied in the prevention of disease, are the result of scientific research by the experimental method, undertaken often without thought of immediate practical utility. While valuable and much desired information is afforded by investigations of the statistician and by observations in the clinic and in the field, the great discoveries which have revolutionized preventive medicine and

which continue to enrich it with life-saving knowledge have come from the laboratory worker and are achievements of the experimental method of research.

The discovery of the tubercle bacillus by Koch in 1882 placed tuberculosis definitely in the class of infectious, communicable diseases, and aroused high hopes of the eventual control of this foremost cause of death. Before the close of the decade, the New York City Department of Health, under the influence of Biggs and Prudden, took the lead, which it has since maintained, in this country, in the attack on tuberculosis as an administrative public health problem.

In the beginning, in conformity with general views which I have already indicated, all the emphasis was placed upon efforts to prevent infection by notification, early diagnosis, anti-spitting ordinances, isolation, and hospital and sanatorium care. Within the next two decades, however, the anti-tuberculosis campaign took shape, assumed proportions, and entered upon activities which more than any other single influence have determined the characteristics of that

phase of the health movement of the last decade which Dr. Winslow in his Yale address calls "the new public health," using this designation in a sense somewhat different from that in which it is used by Hibbert Hill, who finds the characteristic note in more careful supervision and, if possible, the abolition of the sources of infection (concurrent epidemiology).

Had it been in our power to control tuberculosis, as is possible with small-pox, diphtheria, typhoid fever, and several other diseases, by some definite procedure, such as specific immunization, as we hope eventually may be done, there would doubtless have been no anti-tuberculosis campaign of the character which it assumed, and public health would have missed many good things and some possibly less desirable.

Time permits me on this occasion merely to enumerate some of the salient features and contributions to public health of the anti-tuberculosis movement: such as, the more intensive study of the special problems of the disease; the early recognition of its social and economic aspects and thereby of these aspects of health and

preventable disease in general; the enlistment of public interest in health activities; popular education as the key-note of "the new public health"; the participation of voluntary associations in the field of public health; revival of discussions of racial and individual, inherited and acquired, immunity and resistance to disease; the cultivation of the open-air life, exercise and play and increased attention to personal hygiene in general; improvement of living and working conditions; establishment of sanatoria, dispensaries, hospitals, and open-air schools for the tuberculous; of especial importance, the development of public health nursing out of the system of instructive, visiting nursing; travelling exhibits and clinics; periodic medical health examinations; and still other contributions which might be mentioned.

These newer directions of public health, thus imperfectly summarized, have been strongly reenforced and important additions have been made thereto, particularly in the form of medical school inspection, milk stations, and welfare and health centres, by the maternity, infant, and

child hygiene movements, by the anti-venereal disease campaign, which takes the euphemistic name in this country of "social hygiene," by the National Mental Hygiene Committee, by organized popular movements for the control of cancer and for the prevention and relief of heart-disease, and there is no reason to suppose that we have reached the end of similar movements.

When one considers the many open problems and controversial questions of both a scientific and a practical nature in these movements to arouse public interest and to educate the people in various health matters, it is evident that here is indeed a fertile field for the searcher after the working hypotheses guiding modern public health activities. Notwithstanding its pertinence to my theme, it would lead too far for me at this time to attempt a consideration of the hypotheses and ideas concerned.

It is obvious from what has been said that the anti-tuberculosis campaign has become quite as much a general health movement as one specifically directed against the disease, tuberculosis,

and this is now openly recognized. No disease could have served equally well for this purpose. That this campaign has been an important agency in the remarkable reduction in the tuberculosis death rate during the last quarter of a century is my own belief, although it is fair to say that there is disagreement of authoritative opinion on this question. But whatever view may be held on this point, no one can fail to recognize the immense significance of this campaign in the promotion of the modern public health movement along lines which I have attempted to indicate.

In a somewhat different way the campaign for the eradication of hookworm, and more recently of malaria, as conceived and promoted by the International Health Board of the Rockefeller Foundation, has been made to serve as a powerful instrument for improvement of the organization and work of departments of health in our Southern states and in other parts of the world.

I should be inclined to characterize "the new public health" with somewhat less emphasis than is customary upon the mere technique of popular education, important as this is, but rather by its

conscious and definite recognition of the general physical well-being of the people as a vital concern and important activity of organized public health. It is a widening of the public health program, not a substitution for what it previously embraced. Environmental sanitation and the control of communicable diseases, as well as methods of demonstrated value to attain these ends, have lost none of their importance through increased attention given to instruction of the public in personal hygiene and other health matters. These latter aims, of course, are not new; they are as old as the Greeks; but much of the subject matter and the technique are new, and their entrance in a much larger way and in a more systematic, organized form into the modern public health movement is to be welcomed.

Public hygiene has been developed too largely upon considerations of mortality rates without sufficient reference to sickness rates, the reason of course being the difficulty of obtaining satisfactory information concerning the latter. The span of life, as Pearl has demonstrated, is an inherited character, but a long one, as experience shows, is

entirely compatible with valetudinarianism or chronic invalidism. Both sickness rates and death rates are reduced by healthy living, and for the present personal hygiene is a main reliance in the diminution of many non-infectious diseases, particularly the organic affections of advancing years.

Before concluding this address, already too extended, I should like to refer very briefly to a matter which seems to me of serious concern to modern public health.

This is the lack of sufficient active participation of the general medical profession in public health activities, especially as developed in this country. The fault is on both sides. There has been encroachment upon the field of the private practitioner, and there has often been a lack of sympathy and coöperation with health officials and with health programs on the part of practitioners.

The remedy for this unfortunate condition is to be sought in the first instance in improvement of medical education, whereby a sense of responsibility for the health of the community as

well as of his patients is inculcated and the idea of prevention, not less than that of cure, is impressed upon the minds of the students. Lectures and courses in hygiene are not sufficient, and there is little room for them in the already overburdened curriculum. There is no subject of medical study without some bearing on preventive medicine and every teacher should consider it his duty to emphasize these aspects. In a word, as Sir George Newman expresses it, the whole medical curriculum should be permeated with the idea of prevention.

Specialized training for careers in public health is the function of graduate courses or of schools of hygiene established for the purpose of supplying these much-needed opportunities.

How largely the medical profession can actively participate to advantage in community health work is exemplified in the Scandinavian countries where education of medical students is more prolonged and thorough than elsewhere and physicians possess a high sense of responsibility to the community.

There can be no real and lasting success of

efforts to promote the health of the people and to prevent disease without the active sympathy, support, and participation of the medical profession. How this is to be more largely secured merits the most serious consideration.

From the necessarily inadequate review which I have attempted, in this address, of changing conceptions of disease as related to preventive medicine, and of the resulting theories and practices of public health at different periods of history, one lesson can be sharply drawn. This is that success in the control of disease is directly dependent upon accurate knowledge of the causation and propagation of disease. Great as have been the triumphs of preventive medicine in the past, the problems remaining for solution are still greater. The hope of the future lies in the continued and increasing growth of scientific knowledge which can be applied to the relief of human suffering and the saving of human lives.